



Quantification of Inflight Physical Changes: Anthropometry and Neutral Body Posture (Body Measures)

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Agenda

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- Study Description
- Current Status
- Preliminary Results
 - Anthropometry
 - Neutral Body Posture (NBP)
- Summary



Background

- NASA currently lacks sufficient in-flight anthropometric data to assess the impact of physical body shape and size changes on suit sizing and for interior workplace design on future vehicles.
- Current information is limited and is based on SkyLab data with few subjects (n=3).
- Recent study on Spinal Elongation (an HRP study in 2009-2011) was primarily focused on Orion seat configuration (microgravity effects on seated height).



Background

- Suit fit issues in microgravity
 - NASA suit engineers, the EVA Project Office, and the MOD trainers have identified that suit fit in microgravity could become an issue as evidenced during a recent incident on-board the ISS.
 - It has also been noted that crewmembers often need to adjust their suit sizing once they are in orbit.
 - This adjustment could be due to microgravity effects on body shape and size (anthropometry) and posture.
 - Extended hiatus between NBL training and EVA for ISS crewmembers – may decrease familiarity.
- An understanding of how the body changes in microgravity is thus necessary to ensure optimal crew performance, fit, and comfort in space.

Objective

- The goal of this study is to gather preliminary data to better understand the magnitude and variability of microgravity changes on the body.
 - Aim to gather and document microgravity effects on body measurements.
 - Lengths, Breadths, Depths, Circumferences
 - To determine if/how the Neutral Body Posture (NBP) is influenced by the above factors.
 - Joint angles
- First time these proposed measures are collected in space.
- Anticipate that body measurements will change due to microgravity and fluid shifts.
- Data is important so that the changes that may occur during long-duration space flight can be identified and applied to suit fit, suit sizing, workstation design, etc. for future missions in order to prevent injury and reduce crew time for altering or adjusting suits, workstations, etc.

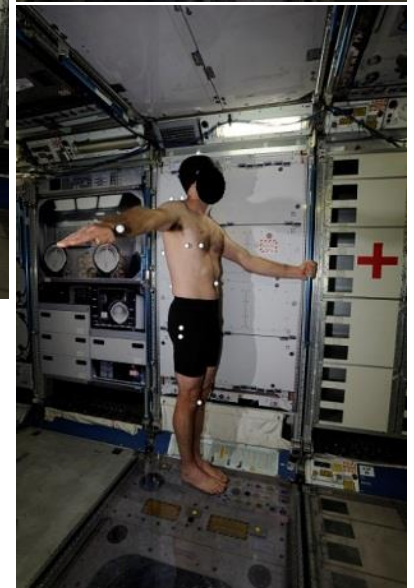
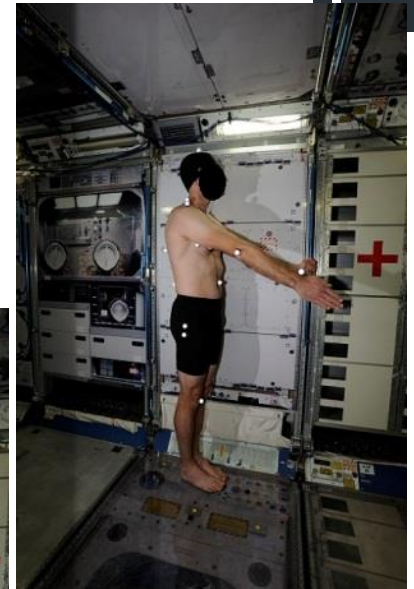
Objective

- Three activities
 - Activity 1: Anthropometric photographs/measurements
 - Collect 3-D photogrammetry for height, breadth, depth, and length measurements
 - Collect circumferences using tape measure
 - Collect measurements using Anthropometer & 3D whole body laser scanner (ground only)
 - Activity 2: NBP
 - Collect video to determine posture and joint angles (in-flight only)
 - Activity 3: Weight/Body Mass Measurement
- Sessions (Pre-, In-, Post-)
 - Pre-flight – anytime after consent
 - In-flight - 3 nominal, 3 reserve
 - Flight day 15, 45*, 80, 105*, 135*, Return - 15
 - Post-flight – return + 20

Study Description: Activity 1

Activity 1: Anthropometric Photographs/ Measurements

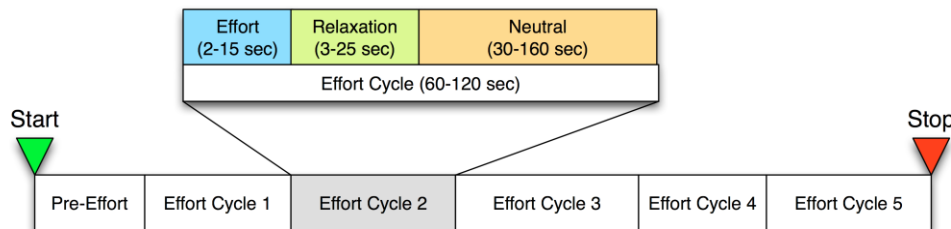
- Collect pre-, in-, and post-flight
- Collect anthropometric measurements using:
 - Anthropometer (ground only)
 - Tape measure
 - Digital still photographs
 - 3D body scanner (ground only)
- Collect two photographs per posture for three specific postures in front of ISS rack
 - front facing posture (front)
 - side with right arm extended 45°(side 1)
 - side with right arm abducted 90°(side 2)
- Collect 3D body scan in same postures as photographs with markers (ground only)



Study Description: Activity 2

Activity 2: Neutral Body Posture (NBP)

- Collect synchronized video of blindfolded subject performing NBP task by 2 cameras.
 - Consists of performing 2 phases; an effort phase (stretch/crouch) and relaxed phase
 - Sequence is repeated 10 times per session, altering and randomizing the effort phase posture.
- Data is used to determine if changes occur:
 - Between Skylab posture and current posture(s)
 - Throughout duration of Mission or if posture stays the same



NBP Effort Phase: Crouch

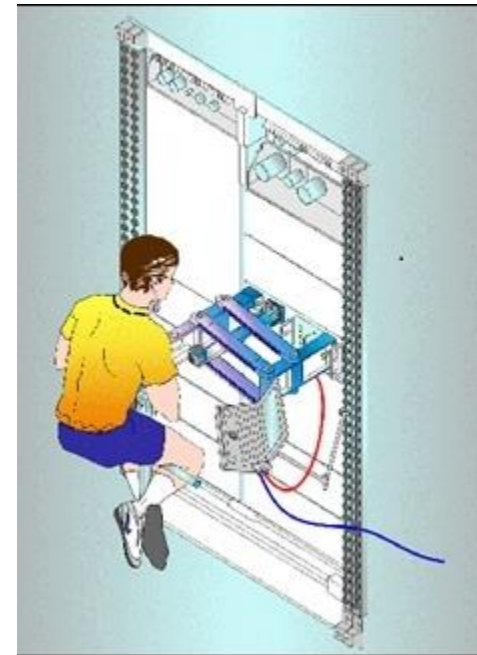


NBP Effort Phase: Stretch

Study Description: Activity 3

Activity 3: Body Mass Measurement

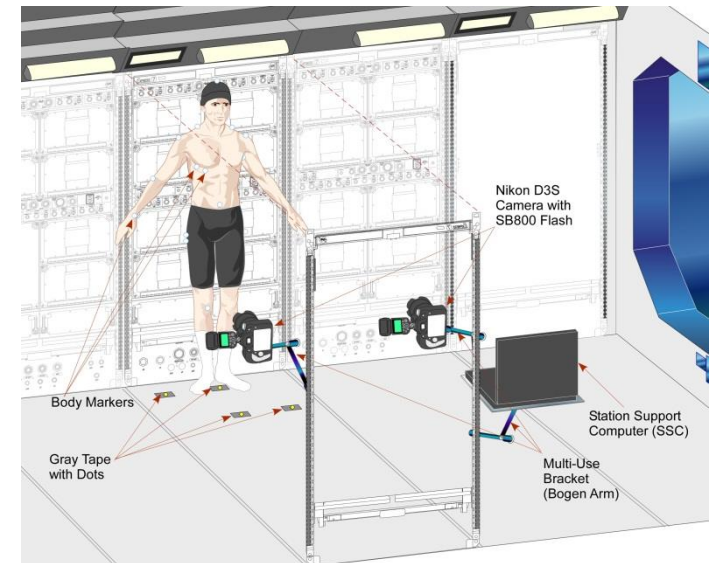
- Collect weight pre- and post-flight
- Collect mass in-flight:
 - Space Linear Acceleration Mass Measuring Device (SLAMMD)
 - Russian Body Mass Measuring Device (BMMD)



SLAMMD Body Mass Measurement

Current Status

- This study is continuing inflight data collection
 - 8 subjects have completed the study
 - 2 subjects completed all reserve sessions
 - 6 subjects have performed On-Orbit Fit-Check Verification (OFV) measurements
 - 12 subjects consented to participate (n=9)
- Continue to analyze and process data



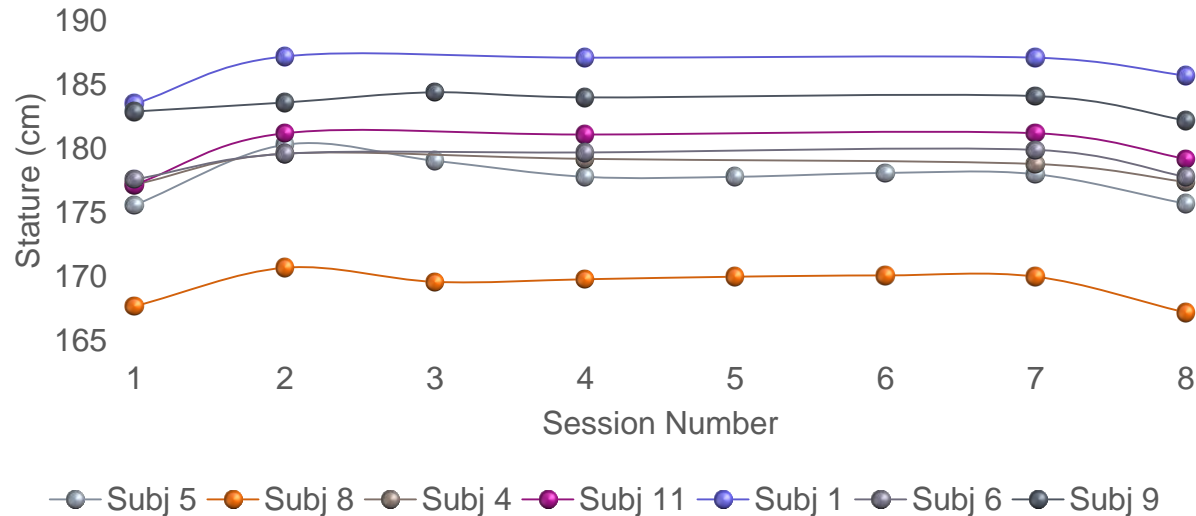
Graphical representation of Activity #1



Preliminary Results - Anthropometry

Preliminary Results - Anthropometry

Stature (cm)



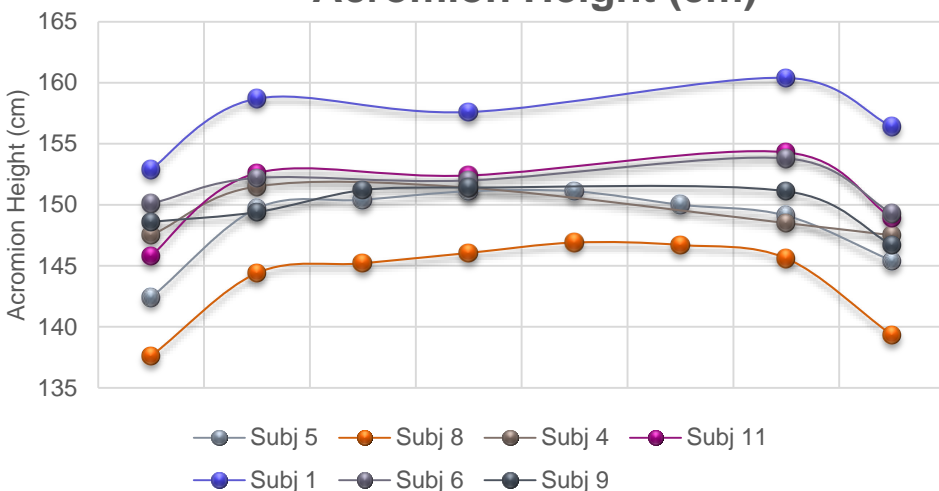
Session #	Description
1	Pre-Flight
2	Flight Day 15 (FD15)
3	Flight Day 45 (FD45)
4	Flight Day 80 (FD80)
5	Flight Day 105 (FD105)
6	Flight Day 135 (FD135)
7	Return – 15 (R-30)
8	Post-Flight Return +20

Stature

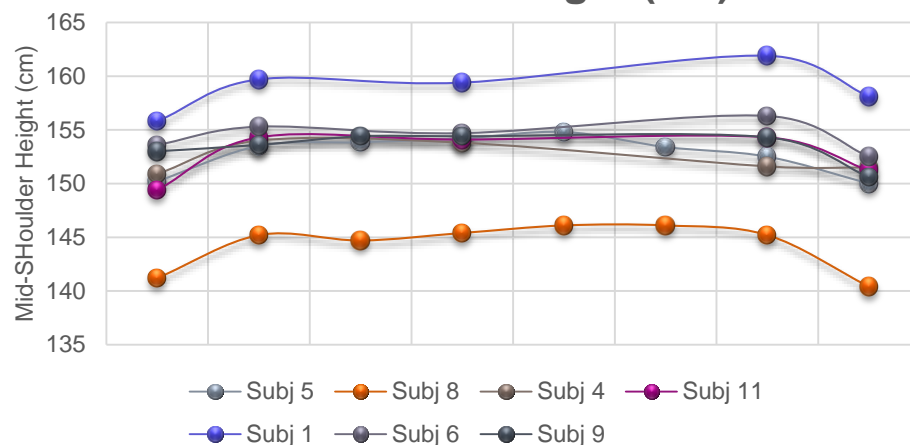
- Similar trend for all subjects
- Similar trend as Sky-Lab results
- Bi-Phasic: Quick increase then plateau
- Mean Stature = 177.4cm (+/- 5.2cm)
- In-flight Mean Growth = 2.6cm (+/- 1.1cm)
 - FD15 = 2.9cm
 - FD80 = 2.4cm
 - R-30 = 2.5cm
- Pre- and Post- flight not significantly different
- Pre- and In-flight significantly different

Preliminary Results: Anthropometry

Acromion Height (cm)

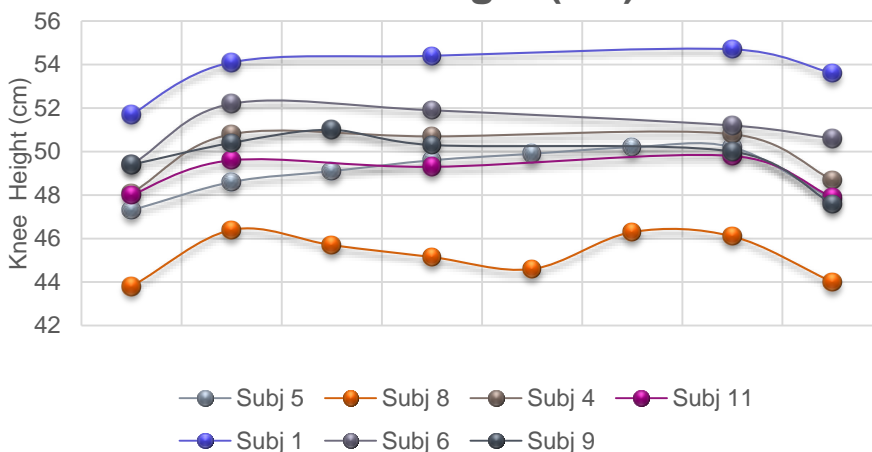


Mid-Shoulder Height (cm)



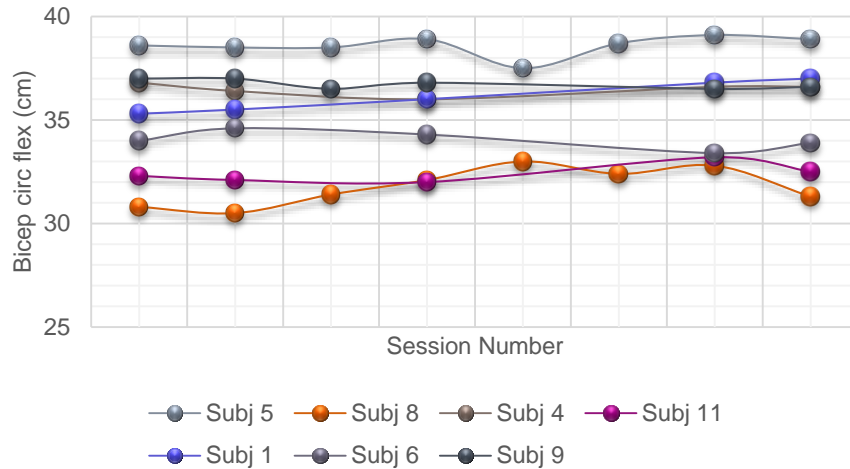
- **Acromion Height**
 - In-flight mean growth = 5.2 (+/-2.6cm)
- **Mid-Shoulder Height**
 - Inflight mean growth = 3.1cm (+/-1.5cm)
- **Knee Height**
 - Inflight mean growth = 2.1cm (+/-0.7cm)
 - Performed ground test to verify that knee ht change is unrelated to stature change.
- **All Heights**
 - All highly dependent on marker location
 - Significant difference between pre-flight and inflight
 - No significant difference between pre-flight and post-flight

Knee Height (cm)

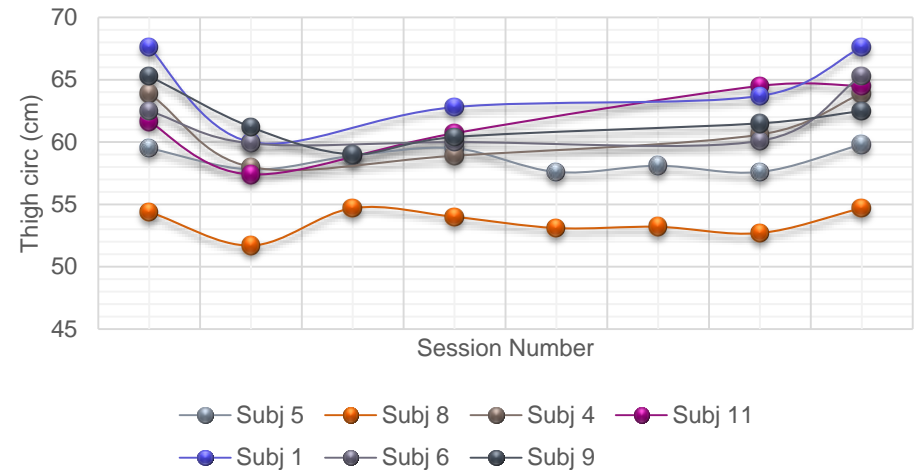


Preliminary Results - Anthropometry

Bicep Circ Flex (cm)



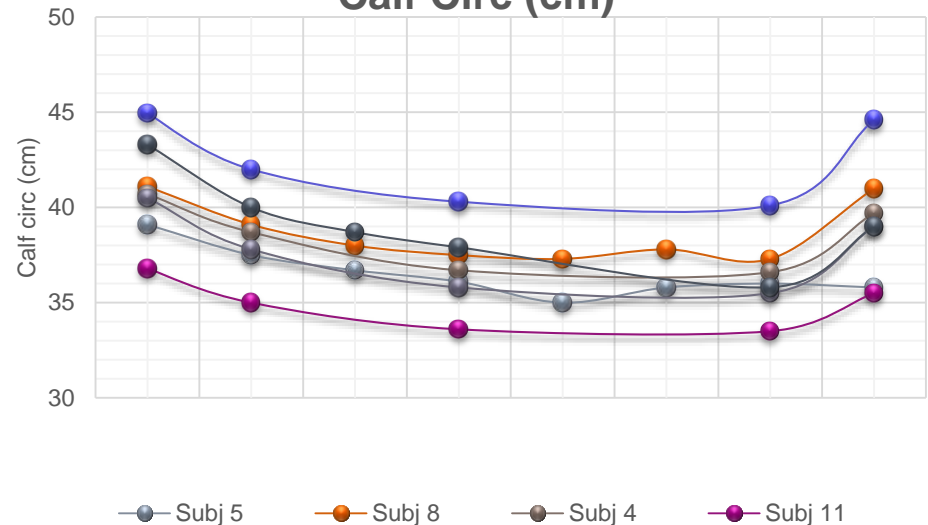
Thigh Circ (cm)



■ Circumferences

- Bicep Circumference Flexed
 - Minimal change throughout Mission
- Thigh Circumference
 - Significant difference between Pre-flight to FD15
- Calf Circumference
 - Steady decrease throughout Mission
 - Significant difference between Pre-flight and Inflight

Calf Circ (cm)



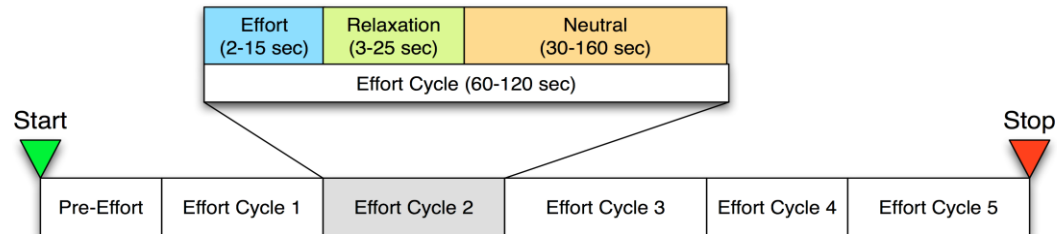
Preliminary Results - Anthropometry

Measurement	Overall	Pre-flight to FD15	Pre-flight to FD80	Pre-flight to R-30	Pre-flight to Post-flight
Stature	Yes	Yes	Yes	Yes	No
Acromion Height	Yes	Yes	Yes	Yes	No
Mid-Shoulder Height	Yes	Yes	Yes	Yes	No
Knee Height	Yes	Yes	Yes	Yes	No
Crotch Height	Yes	Yes	Yes	Yes	No
Waist Circumference	Biphasic	No	Yes	Yes	No
Hip Circumference	Biphasic	Yes	Yes	No	No
Thigh Circumference	Biphasic	Yes	No	No	No
Calf Circumference	Yes	Yes	Yes	Yes	No
Hip Height	No				
Biacromion Breadth	No				
Hip Breadth	No				
Chest Breadth	No				
Chest Depth	No				
Waist Depth	No				
Upper Arm Length	No				
Lower Arm Length	No				
Chest Circumference	No				
Bicep Circumference, flexed	No				



Preliminary Results - Neutral Body Posture

Preliminary Results: NBP

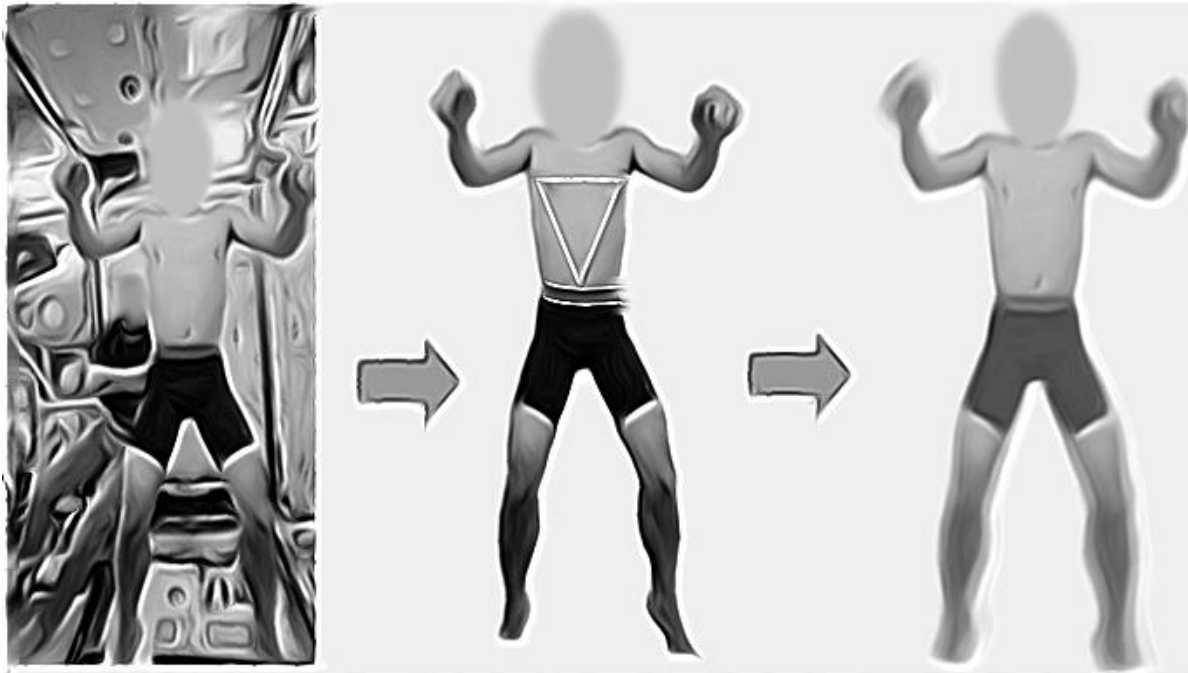


■ Observations:

- Relatively stable behavior for veterans
 - Longer period of time in neutral phase
- Increase in relaxation and neutral phases throughout Mission
- S1: Similar postures intra-effort-wise but differ inter-effort-wise
- S2: Similar postures intra-effort-wise but different inter-effort-wise

Preliminary Results: NBP

- Stability Analysis (Overlay method)
 - Used bust point, belly button, and waist band as references
 - Overlay all postures after same effort
 - Determined difference between and within data collection session

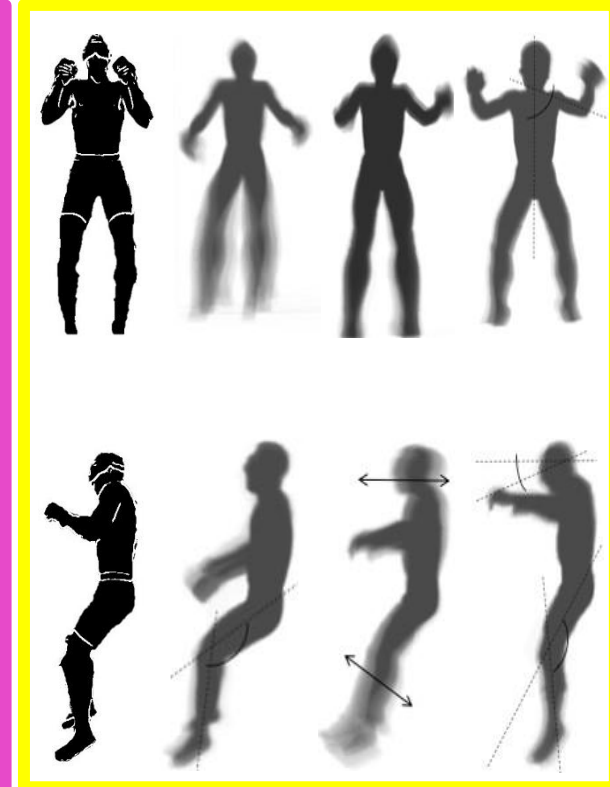
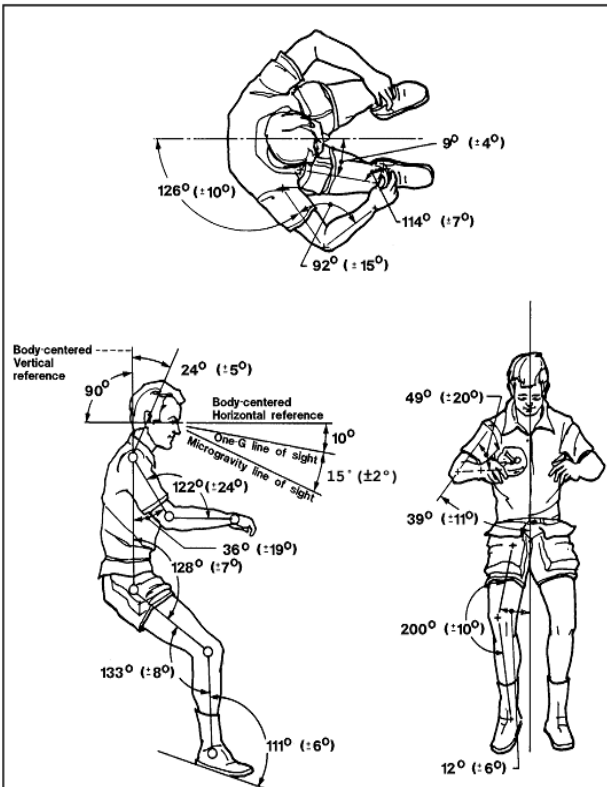


Preliminary Results: NBP

NASA-STD-3000

Crouch

Stretch



S1: Crouch similar to NASA-STD-3000

S2: Stretch experiment 2 similar to NASA-STD-3000

Stretch: Hands are higher than NASA-STD-3000 posture

Summary

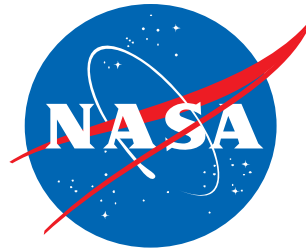
- Anthropometry

- Stature – similar results as Skylab, biphasic, max growth of 3% pre-flight
- Calf Circumference – decreases throughout Mission 1.6-5.0cm (4%-11%)
 - Exercise may reduce loss to some extent
- Growth for most measurements are statistically significant

- NBP

- Increase in stability as familiarization of microgravity increases
- Relatively stable behavior for veterans
- Increase in relaxation and neutral phases throughout Mission
- S1: Similar postures intra-effort-wise but differ inter-effort-wise
- S2: Similar postures intra-effort-wise but different inter-effort-wise

Questions?



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Backup

Experiment Design Overview

Measurements to be collected

Measurement	Pre-flight	In-flight	Post-flight
Stature	A, P, L	P	A, P, L
Acromion Height	A, P, L	P	A, P, L
Mid-Shoulder Height	A, P, L	P	A, P, L
Knee Height	A, P, L	P	A, P, L
Hip Height	A, P, L	P	A, P, L
Biacromion Breadth	A, P, L	P	A, P, L
Hip Breadth	A, P, L	P	A, P, L
Chest Breadth	A, P, L	P	A, P, L
Chest Depth	A, P, L	P	A, P, L
Waist Depth	A, P, L	P	A, P, L
Upper Arm Length	A, P, L	P	A, P, L
Lower Arm Length	A, P, L	P	A, P, L
Crotch Height	A, T, L	T	A, T, L
Chest Circumference	T, L	T	T, L
Waist Circumference	T, L	T	T, L
Hip Circumference	T, L	T	T, L
Bicep Circumference, flexed	T	T	T
Thigh Circumference	T	T	T
Calf Circumference	T, L	T	T, L
Weight/Mass	Scale	SLAMMD	Scale
NBP	-	V	-

A – Anthropometer
P - Photographs
T - Tape Measure
V – Video
L – Laser Scanner